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SOVIETS BUILD FULLY AUTOMATIC PLANT FOR ALUMINUM-ALLOY PISTONS

AUTOMATIC PLANT GOES INTO OPERATION -- Paris, l'Humanite, 24 Mar 51

The first automatic plant in the world has just begun operation in Moscow. The plant receives aluminum ingots and turns out pistons for truck motors in boxes of six. One man seated at a desk operates the entire plant, which is small and horseshoe shaped, with sides about 50 meters long.

The plant was designed by Vladimir Dikushin, corresponding member of the Academy of Sciences USSR and director of a group of designers. Dikushin received a 1950 Stalin First Prize, and his 24 associates, engineers, assemblers, and scientific workers were also rewarded.

MAKE ALL PROCESSES AUTOMATIC, FROM CASTING TO PACKAGING -- Moscow, Avtomobil'naya i Traktornaya Promyshlennost', Mar 51

The automatic lines for making aluminum pistons, planned by the Experimental Scientific Research Institute for Metal-Cutting Machine Tools (ENIMS) and built by machine-tool-building plants, represent a major advance in the complex mechanization of technological processes. Every operation in the manufacture of pistons, from casting to packaging, has been made automatic and coordinated with the other operations.

The automatic plant has two complex parallel lines for processing aluminum pistons for GAZ-MM and ZIS-150 trucks. The first automatic line, turning out ZIS-150 pistons (part No 120-1004015), is now being set up at one of the plants of the Ministry of Automobile and Tractor Industry.

There are four stages in the making of a piston; casting in a chill mold, heat treatment, machining, and tinplating. In addition, the pistons must be sorted into groups and packaged. All the equipment on the lines is partitioned into technologically independent sections connected by automatic conveyers.

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Casting Section and Metal Storeroom

An aluminum-copper-silicon alloy is used for casting the pistons. The chemical composition of this alloy is as follows: copper, 5-7 percent; silicon, 4.5-6 percent; iron, no more than 1.2 percent; zinc, no more than 0.5 percent; manganese, no more than 0.5 percent; magnesium, no more than 0.5 percent; and the remainder, aluminum.

This alloy is made from secondary aluminum, type AL-25, GOST 1583-47, with a magnesium content no lower than 0.2 percent, in ingots 590 x 155 x 110 millimeters, weighing 15 kilograms, plus or minus 1.5 kilograms, combined with scrap from the production line in the form of gates and rejected pistons.

Movable belt conveyers carry the aluminum ingots from railroad cars to the storeroom, located in front of the casting section. Here the ingots are loaded into metal containers holding 650 kilograms each, which simultaneously take specimens for chemical analysis. The ingots are sorted into four groups according to silicon content: I, 4.5-5 percent; II, 5-5.5 percent, III 5.5-6 percent, IV, 6-6.5 percent.

The sorted ingots are fed, in the containers, to a conveyer washing machine by an electric monorail traveling crane. After washing, they are dried by compressed air and placed in skids near the smelting furnace, where a 2-day supply of ingots is kept.

The casting section is made up of the following fully automatic machines: an electric smelting furnace, a rotary casting machine, and an aggregate milling machine for cutting off deadheads.

The aluminum ingots and rejected pistons are fed by hand onto the horizontal section of an intermittent-action, twin-chain slat conveyer which carries them to the loading platform of a multiple-zone, reverberatory, electric smelting furnace. Loading of the ingots and scrap into the furnace takes place in periodic intervals, depending on the time it takes to make 12 castings on the casting machine. The furnace is loaded by a horizontal hydraulic plunger situated under the conveyer. The feeding of ingots is regulated by a special relay system. The smelting aggregate is a five-zone resistance furnace of the reverberatory type, with a metal accumulator.

The temperature of the metal in the furnace is held between 800-850 degrees centigrade. In the metal discharge zone (the fifth zone) and other zones, the temperature of the metal is regulated by thermocouples. The temperature in the metal accumulator is automatically held between 690-710 degrees centigrade, and a thermocouple in the smelting zone shuts off the heaters if there is danger of overheating.

Chlorine gas from a special installation, under a pressure of 100 millimeters of mercury, automatically refines the molten metal in the accumulator. Once or twice every 24 hours a specimen is taken from the metal accumulator for spectrum analysis. Painstaking control of the chemical composition of the ingots, automatic regulation of the temperature, and refining of the alloy provide molten metal of fixed properties and constant temperature.

The molten metal flows from the accumulator in a constant stream to the six-position rotary casting machine, which pours it into permanent chill molds. The casting machine performs the following automatic operations:

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1. It fills the chill mold with molten metal by means of a needle pouring-measuring device. An electric relay times the pouring so that the proper amount of metal is measured out.

2. It raises the middle key of the core 50 millimeters and simultaneously draws out the cores for the piston pin holes 2.5 millimeters. It moves both sides of the main core 0.8 millimeters toward the center.

3. It raises the middle key 460 millimeters, brings together and removes the sides of the core, pulls the piston pin hole cores out completely, disassembles the die, and ejects the casting.

4. It assembles the three elements of the core: the key and the two sides.

5. It cools the lower part of the assembled core in graphitized water.

6. It assembles the chill mold.

In addition, the machine has the following units: a mechanism for emergency removal of the dies in the first or pouring position, a tank for mixing and feeding graphitized water to the core-cooling mechanism in the fifth position, and a system of cooling the dies with tap water. The temperature of the external surfaces of the dies and the center cup should be 320-340 degrees centigrade.

The casting is removed in third position by a walking conveyer. The upper part of the conveyer has a horizontal movement of 500 millimeters and a vertical movement of 90 millimeters, transmitted from hydraulic cylinders. As the cradle on the conveyer completes its upward motion the dies of the chill mold separate and the casting drops onto the conveyer. The casting travels 500 millimeters and then stops as another casting is dropped onto the next cradle. Moving along the conveyer in stages, the castings are brought to an aggregate milling machine which cuts off the gates. The unique thing about this operation is that the gates are cut off while the temperature of the casting is 200 degrees centigrade. The casting does not have a chance to cool, but is immediately conveyed into an annealing furnace, thus reducing the consumption of electric power.

Side milling cutters with inserted VK8 alloy blades operate at a cutting speed of 250 meters per minute, and a feed of 490 millimeters per minute, removing the gates and risers. The upper-face miller, which removes the fins from the open face of the piston. travels forward with respect to the side millers and operates at rapid feed of the milling head. When the piston is released by the hydraulic clamps which hold it during the milling operation, it travels one more step along the walking conveyer. A pin mounted on the milling head pushes the piston onto a transverse automatic reloader which collects eight pistons and places them on a rack (skliz) in horizontal position. A plunger than pushes the pistons onto the annealing furnace conveyer, eight at a time.

Heat Treatment Section

To improve their mechanical and machining properties, the castings undergo prolonged annealing (aging) in a continuous-action conveyer furnace equipped with electric heaters. The furnace is made of welded sections with bolted joints. The inside of the furnace is divided into three longitudinal

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sections, one on top of the other. The twin-chain slat conveyer is of the propelling type. The bars joining two opposite rollers on the chain are plunger-carriers which roll the pistons across the metal conveyer bed. The lining of the bottom and sides of the conveyer are made of diatomite brick and firebrick.

The heaters, mounted on the roof of the furnace, consist of nine nichrome-wire heating elements, wound on firebrick tubes, mounted on the cores of the frames.

The furnace has a hot-air blowing system and a cooling system, both located in the area over the crown of the furnace. The hot-air system works on the closed circulation principle. Air is blown into the furnace through the heater and directed to the three levels of the furnace. The air returns to the blower through a suction pipe. The temperature of the air taken in is automatically regulated by a thermoregulator.

During the first 30 minutes, the piston is heated to 250 degrees, plus or minus 5 degrees centigrade, and held at that temperature for 5.5 hours. The piston is cooled to a temperature of 20-50 degrees centigrade when it is conveyed from the furnace into a chamber cooled by air at a temperature of 18-20 degrees centigrade. The piston remains in this chamber 32 minutes. The complete annealing cycle takes 6 hours, 56 minutes.

Five thermocouples are installed in the furnace. The thermocouple placed at the point where the castings and the hot air enter is connected with a thermoregulator which automatically controls the power of the heater. The thermocouples placed at the exit from the furnace and in the middle of each section are for checking purposes. They are connected to automatic recording instruments, thus making it possible to control the temperature in any part of the furnace automatically.

From the annealing furnace, the cooled castings are conveyed to the rack of the hardness-testing press in rows of eight. The pistons should have a Brinell hardness of 100-130 after heat treatment. The casting is pressed to the support block of the press by a force of 1,200 kilograms. A rod from above, with a ball 5 millimeters in diameter, is pressed into the casting to a depth of h with a preliminary load of 70 kilograms. Then, under the action of the basic load of 750 kilograms for a period of 2.3 seconds, the ball penetrates to a depth of h_1, after which the load is removed.

An electric contact tip measures the difference in depth between the indentations h and h_1. If the casting is not sufficiently hard, the contact tip gives an impulse to an electromagnetic mechanism which rejects the piston through an electric relay. The castings are conveyed in rows of eight to the storage bin, which has a capacity of 2,000 pistons and is located in front of the line of automatic machine tools.

Thus, in the metallurgical sections of the shop, all the technological, transport, and control operations are fully mechanized, with the exception of the hand loading of the aluminum ingots onto the smelting furnace conveyer. This conveyer has a capacity of 65 ingots and its horizontal section holds 28 ingots. One unskilled laborer can load enough ingots in 4-5 minutes for an hour's operation of the conveyer.

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Machining Section

The machining section consists of a hand-loaded machine tool located outside the line of aggregate machine tools, for machining the bases of the pistons, an automatic machine-tool line joined with a conveyer tinplating aggregate, a special machine tool for final machining of the piston-pin holes, and an automatic checking and sorting machine.

Machining begins with the facing of the skirt, the reaming of two aligning holes in the inner ribs of the open face of the piston, and the drilling of a center hole in the head of the piston. (In the second automatic line, for GAZ-MM pistons, the machine tool for machining the bases is located in the automatic line.)

The automatic line has an improved control system which does not give the impulse for starting aggregates until it receives a signal that the preceding operation has been completed. A special holding block with two aligning pins conveys the piston through all the machining operations. A pneumatic lifting table delivers four holding blocks to the machine-tool operators' working place, located between the storage bin for castings and the automatic machine-tool line. The machine-tool operator places four pistons on the holding blocks by hand, and the pistons and blocks go from machine tool to machine tool on a conveyer.

The blocks holding the pistons are distributed along a tenon-shaped rail, and T-shaped tongues serve to fix the blocks when they are on the machine tools. The manner of fixing the piston and holding block is the same on all the machine tools on the line. In the working positions, fixing pins, set in motion by a hydraulic system, enter the center holes of each block. The pistons are clamped by hydraulic centers or by special flat clamps.

There is a special mechanism for setting the block and piston on a machine tool which performs operations requiring rotation of the piston.

The automatic line consists of special aggregate machine tools which machine four pistons at a time. The attachments on all the machine tools are of the same design.

An aggregate two-position machine rough bores the piston pin and centering holes. The spindles of the centering drills and the flat clamps are situated on top of the machine tool.

The aggregate multicutter lathe has four vertical spindles in a row and two horizontal power heads fitted with slides. The left head is stationary and is designed to machine while the slide moves downwards. The right head travels horizontally and machines the external diameter of the piston. The right head has intermittent feed, and changing from fast to slow feed is automatic.

The aggregate vertical-milling machine has a special mechanism for turning the pistons and blocks 90 degrees on their axis for milling the horizontal slots. After milling, the blocks and pistons rotate back to their original position and move along the rail to the next operation.

The machine tool for drilling the oil holes has a mechanism which indexes the piston and block to the angle at which the holes are to be drilled. Moreover, it has an interlocking device which stops the machine tool and the whole automatic line if a hole is not drilled. Similar interlocking devices stop the line if piston pin and centering holes are not drilled and if the piston ring grooves are not cut.

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The oil holes are drilled in this order: two holes are drilled simultaneously on opposite sides of the piston, six more holes are drilled individually at intervals of 20 degrees, and finally, two more holes are drilled simultaneously on opposite sides of the piston, 20 degrees away from the first pair of holes. The two-spindle cylindrical-grinding machine has two grinding wheels with vertical rotation axes. Each wheel grinds two adjoining pistons simultaneously. Two hydraulic mechanisms for truing the grinding wheels are located on the wheel slides. The wheels are regularly trued once every two shifts. The pistons rotate at 33 meters per minute (100 revolutions per minute) and cross feed of the wheels is 0.03 millimeters per revolution.

Use of the holding blocks ends at the aggregate which machines the pistons down to weight. From this point, the blocks are returned to the beginning of the automatic line on a smooth guide rail which passes under the machine tools slightly above the level of the floor.

The five-position automatic machine for machining the pistons down to weight is a highly productive aggregate of original design. From here, the pistons go to another aggregate for finish grinding of the surfaces.

The special centerless grinding machine has four wheels and its own conveying and loading mechanism in the form of a lifting-turning table. The horizontal sleeve of the loader collects four pistons in two movements, rises, turns through an angle of 90 degrees in a horizontal plane, and lines up with the guide mechanism of the centerless grinding machine. This machine's work cycle is fully automatic. A rake on the conveyer pushes four cylinders along two guides into the working position. The grinding wheel head is fed in rapidly as soon as the cylinders are in position. One of the guide arms swivels aside, the pistons are lowered onto the working knife edge, the drive gear is engaged, and the loading table descends out of the way. When the grinding head is withdrawn rapidly, the guide arm of the conveyer turns, lifting the pistons from the working knife edge. When this rapid motion of the grinding head ceases, the rake moves up with a new set of pistons and pushes the machined pistons onto a rack.

The conveyer of the tinplating aggregate is a horizontal closed-chain type fitted with sets of four pins. The pistons are loaded onto these pins in a vertical position with the heads up for the tinplating operation. The concentration of the tinplating solution is controlled automatically. From this machine, the pistons are conveyed to an automatic bin located in front of a machine tool which does the final machining of the piston-pin holes.

The special aggregate machine tool for final machining of the piston-pin holes has eight four-place attachments and four groups of tool heads for boring holes and lock grooves. The machine tool has 16 spindles and performs its operations in eight positions: (1) placing of four pistons; (2) fixing of cylinders by the piston-pin holes; (3) preliminary and final drilling of holes; (4) boring of lock-ring grooves; (5) transverse movement of the holding device; (6) broaching of holes in line; (7) precision lapping of holes; and (8) idling position.

Next, the pistons go to the washing machine and must be loaded onto the forks of the washing-machine conveyer by hand. As the pistons approach the checking and sorting machine after washing, they are removed from the forks and placed on another conveyer.

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The over-all length of the automatic machining section, from the machine tool for rough boring of the piston-pin holes to the packaging machine is 45 meters.

Thirty-four different designs of cutting tools are used for machining the pistons on the automatic line. Cutting tools and reamers of all types tipped with VK3 and VK8 hard alloys, are used. A total of 140 cutting-tool units, ten grinding wheels, and four lapping heads are used on the automatic line at one time.

The following table describes the various machining operations briefly and lists the machine tool used in each operation.

Operation	Equipment
1. Machining of bases	A-900 special ten-spindle, vertical-aggregate drilling machine with four-position table, hand loading
First position: set up and remove two castings	
Second position: face the skirt, chamfer the inside diameter	
Third position: drill two aligning holes for reaming	
Fourth position: ream two aligning holes	
2. Drilling of piston-pin holes and center hole of head	A-901 special three-side, 20-spindle aggregate drilling machine
First position: countersink piston-pin holes from both sides, drill center hole	
Second position: bore holes from two sides with a countersink	
3. Preliminary machining, cutting of grooves, and facing of head	A-903-904V special two-side, horizontal-aggregate multi-cutter lathe
Left head: rough facing of head to a length of 34 millimeters on rapid feed, cutting of four piston-ring grooves at slow feed	
Right head: rough machining of external diameter	
4. Milling of horizontal slot	A-905 special four-spindle, aggregate vertical-milling machine
5. Final cutting and sizing of grooves and facing	903-904G special two-side, horizontal-aggregate multi-cutter lathe
Left head: final facing of piston head and sizing of piston-ring grooves, final machining of lower land, chamfering of skirt and land	

Operation	Equipment
Right head: final machining of skirt and three upper lands	
6. Checking dimensions of piston-ring grooves	A-906 automatic checking instrument
7. Drilling of ten oil holes	A-907 special two-side, eight-spindle aggregate, horizontal-drilling machine
8. Rough grinding of center of skirt and three lands	A-910 special two-side, two-spindle cylindrical grinding machine
9. Milling of diagonal slot: removal of center nipple	A-908 special two-side, eight-spindle aggregate milling machine
Horizontal head: mill diagonal slot 1.5 millimeters wide	
Vertical head: cut off center nipple, remove piston from holding block automatically	
10. Machining pistons down to weight	PPV-5 special five-position automatic machine for machining down to weight
a. Place and clamp two pistons	
b. Rough bore inner ribs, chamfer edges	
c. Loosen jaws, put two pistons on scales, weigh and reclamp them	
d. Bore inner ribs to bring weight of piston to 827 plus or minus 3 grams	
e. Release the two pistons, place them on receiving tables, turn table 90 degrees, and place pistons on rack in a horizontal position	
11. Final grinding of skirt and three lands to a surface finish, with a [root mean-square rating?] of 1.6 microns	3A82P special four-spindle centerless grinding machine
12. Tinplating: degrease in a water solution, solution, wash in hot running water, tinplate in a solution of industrial sodium stannate, wash in cold water, and wash in hot running water	A-923 special conveyer aggregate with automatic loading and unloading of pistons
13. Final boring of piston-pin holes and grooves for the lock rings	A-912 special, horizontal 16-spindle machine tool for final machining of piston-pin holes, hand loading
a. Rough and final boring of two holes in a line	

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Operation	Equipment
b. Boring of two grooves for lock rings	
c. Broaching of two holes in line	
d. Lapping of two holes	
14. Washing of piston in a soda bath and in plain water; drying and cooling with compressed air	MM-1 special washing machine, hand loading
15. Automatic checking, sorting into groups according to piston-pin hole sizes and skirt diameters, marking according to sizes	KPR-1 special automatic machine for checking and sorting
16. Visual checking, inspection	Done by worker
17. Anticorrosion coating and packaging	A-924 automatic-packaging machine

A scraper conveyer travels under the line of machine tools and carries the metal shavings to a belt conveyer, which in turn carries them to a compressing machine. The compressed shavings are carried to a bin by a vertical elevator, and from here they are gravity loaded into trucks.

The aggregate machine for packaging the pistons performs the following operations:

1. It covers the surfaces of six pistons with a thin film of gun oil (GOST 3005-45) at a temperature of 100 degrees centigrade.

2. It cuts sheets of paper 400 x 200 millimeters in size, pushes six parts through a shaft for wrapping, wraps them in paper, and stuffs the ends of the paper inside the open faces of the pistons at the same time.

3. It feeds the pistons into a box, closes the flaps of the box, seals the box with a gummed strip, and places it on a conveyer.

Twelve pistons are in the process of being packed into boxes at the same time.

Technical Control

The following forms of control are utilized to regulate the quality of the pistons:

1. Complete automatic control on the aggregate machines to regulate the following properties and dimensions: hardness of the castings, diameter of the piston-pin holes, diameter and conicity of the skirt, perpendicularity of piston-pin hole axis with respect to the piston axis, the distance of these holes from the head of the piston, and the presence of oil holes.

2. Complete visual inspection of external appearance and checking for the existence of casting defects at the beginning of machine-tool line; and checking for defects uncovered by machining prior to packaging.

3. Selective control of all dimensions affecting the quality of the pistons is carried out by setup men and the Department of Technical Control by means of special multimeasuring control devices with visual reading. Selective control is effected not by testing quality, but by assuring the normal flow of the technological process.

Automatic devices with electrical contact transmitting elements are the basic means of checking dimensions. Special electropneumatic transmitting elements, in which a mercury manometer closes the contacts, are used for pneumatic measuring on the automatic checking-sorting machine.

Organization of the Plant and Accounting

The casting and heat-treatment sections of the plant work three shifts and the remaining sections work two shifts. In view of the variety and complexity of the equipment, the period between repairs is set at 35 days in the casting and heat-treatment sections, and at 69 days in the machine-tool sections.

To assure evenly-paced and uninterrupted operation of all the equipment in the automatic line, mechanized bins holding spare semifinished parts are located at various points in the production line. The first bin, already mentioned above, is located between the casting heat-treatment sections and the machining section, and holds enough castings for 8 hours' work in the machining section. This bin compensates for the difference in tempo between the sections.

The other two bins are located in front of the automatic machine-tool line and in front of the aggregate for final machining of the piston-pin holes. The former bin holds enough parts for one hour's work, the latter holds enough for about $2\frac{1}{2}$ hours' work. These bins assure uninterrupted operation of their sections in the event that the preceding aggregate breaks down.

The loading mechanisms of the machine tool for machining the pistons down to weight and the centerless grinding machine are so designed that they can be hand loaded and unloaded in the event that the neighboring machine tools stop.

The central dispatching point is equipped with a signal panel and telephone communications. The panel has colored signals that indicate which machines are operating and which have stopped. In addition, the panel has electric counters which record the number of castings, castings rejected because of insufficient hardness, parts machined, satisfactory finished pistons put out by the checking-sorting machine, and packaged pistons.

Each machine has a red signal light which flashes on automatically if the machine stops.

According to plans, six worker-operators and 12 setup men (not counting controllers, administrative personnel, and repair and tool-supply servicemen) will be needed for maintenance of the automatic plant's equipment (on both lines).

The maintenance crew looks after the automatic machines and sees that the tools are adjusted and replaced on time. The cutting tools last from two to six work shifts. The third shift adjusts and replaces cutting tools according to a compulsory schedule. To shorten the time required to change and adjust tools, especially on the multicutter lathe, special tool holders, adjusted on an indicating device ahead of time, are used. Grinding wheels require truing no more than once or twice in two shifts. Setup men, repair mechanics, and electricians carry on day-to-day servicing of equipment on the third or adjusting shift.

The shop has all the necessary auxiliary services, including a quick-analysis chemical laboratory for the casting and heat-treatment sections. Special types of coolant emulsions for the cutting tools and grinding wheels are centrally prepared distributed to all the machine tools except the grinding machine by a central circulating system. The grinding machine has an individual cooling system.

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Efficiency of the Plant

ENIMS' (Experimental Scientific Research Institute for Metal-Cutting Machine Tools) preliminary data on the equipment of the first line of the automatic plant, compared to 1950 data for an existing nonautomatic shop making the same pistons, are given in the following table. The comparison is made on the basis of almost identical output in the two types of shop. The indexes of the nonautomatic shop are taken as 100 percent:

Specific Index	Projected Indexes of the First Line of the Automatic Plant (percent of indexes of the nonautomatic plant)
Actual yearly output	85.7
Labor consumption per piston	19.7
Production area of the shop	72
Total number of workers in three shifts	25.4
Total number of workers in three shifts including production workers (setup men and operators)	17.2
Average monthly output per worker	334
Average monthly output per production worker	504
Rated power of electrical equipment	90

Many of the machine tools in the automatic line can be used outside the line for independent work in the automobile plant. In addition, the line can be reset to make repair-size pistons and GAZ-MM pistons.

RECOUNT HISTORY OF THE AUTOMATIC PLANT -- Moscow, Znaniye-Sila, Apr 51

The Experimental Scientific Research Institute for Metal-Cutting Machine Tools and the Moscow Stankokonstruktsiya (Machine-Tool Design) Plant have built a number of aggregate machines and automatic lines in the postwar period, but in designing the automatic piston line they were faced with the task of making all processes automatic, by the application of complex mechanization.

Making a process such as casting automatic presents great difficulties. One big plant spent several years building an automatic piston-casting machine, but could not get it to operate reliably, and so the problem remained unsolved.

V.I. Dikushin, A.A. Levin (associate, ENIMS), and A.G. Gavryushin (associate, ENIMS), chief technologist, designed the machine tools in such a way that the parts could be carried from one aggregate to another by a simple conveyer.

After several months of persistent and painstaking work, the project was organized; after several more months, the first machine tools and machines were set up in a specially constructed building. Assembly of individual aggregates and of the entire plant began under the direction of A.P. Vladzievskiy, ENIMS director docent, and candidate in technical sciences, and A. Ye. Prokopovich, chief

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engineer. Many technologists, designers, and workers of other scientific-research organizations, and of plants of the Ministry of Machine-Tool Building participated in the design and construction of the plant. Workers of the All-Union Scientific Research Tool Institute, headed by Ye. P. Nadeinskaya, director, I.I. Semenchenko, chief engineer, designed and tested special cutting and measuring tools for the plant.

Associates of the Scientific Research Bureau of Interchangeability, headed by I. Ye. Gorodetskiy, director, developed original control and measuring instruments.

Workers and engineers of the Moscow Kalibr Plant and the Moscow Tool Plant built control and measuring instruments and measuring-cutting tools for the plant. The Moscow Krasniy Proletariy Plant built the automatic casting machine and the machine tool for cutting off gates. Workers and engineers of the Moscow Machine-Tool Plant imeni Ordzhonikidze built the packaging machine and the Dmitrovsk Milling-Machine Plant built the automatic bins.

Workers of the Technical Administration, Ministry of Machine-Tool Building, headed by A.P. Rybkin, chief of the administration, and D.V. Charnko, chief technologist, gave great assistance in designing and building the plant.

The casting-heat treatment sections of the plant presented the most difficulties, and dozens of unexpected problems presented themselves to G.A. Bobrov and Ye.M. Morozova, workers in ENIMS' metallurgical laboratory; to V.A. Zakharov, designer of the automatic casting machine; to Ya.V. Loginov, and to Kubyshkin, and A.F. Sorokin, setup men, when they started setting up all the machines in the section.

An undisputed technological law states that all moving parts of a machine must be lubricated, and the designer of the automatic casting machine followed this rule. But the machine began turning out defective castings because the lubricating oil was dripping onto the hot castings and spoiling them. It took much effort to construct a machine that worked dependably without lubrication.

To take another example, the shut-off needle for the casting-machine injector has to withstand the high temperature of the molten metal and to measure the amount of metal injected into the mold to an accuracy of 30 grams. The aperture of the injector and the height to which the needle is raised were carefully calculated, and still the most varied amounts of metal -- any except the amount required by the calculations -- were poured into the molds. It took 3 months to straighten out this situation. It seemed that various parts of the injector deformed under the effect of the heat, and as a result, the height to which the needle was raised was altered. The designers devised a means of moving the injector needle which was not affected by heat expansion of parts of the injector, and a hard alloy needle which was not affected by the molten aluminum.

For a long time, the machine for cutting off gates was a bottleneck because the milling cutter became dull after removing 30-40 gates. The milling cutters soon became clogged with soft metal owing to the heat of the castings. Engineer Turchaninov changed the design of the milling cutters and the work method, and thus increased wear resistance of the tool 50 times. Then Turchaninov, aided by engineers, Naryshkin and Gerasimov, designed a milling cutter with strips of hard alloy attached by mechanical means, which machined 50,000 parts before getting dull.

Then, shavings became a problem, for 75 kilograms of scrap had to be removed per hour. Instead of falling onto the conveyer set up for that purpose, the shavings flew to all sides and got inside the piston and under the supporting blocks which carry the piston from one operation to another. These shavings threw the blocks out of adjustment and sometimes stopped work altogether.

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G.I. Zuzanov, chief of the machining section and Stalin Prize Winner; I.A. Bakulin, Koref, Kolodnyy, and V.I. Shcherbakov, engineers; Il'yina and Kol'ner, technologists; Shepelev, Klopovskiy, and Nikiforov, setup men; and many others, unsparing of their own time, struggled with the stubborn shavings and finally hit on the scheme of blowing them off with compressed air at fixed intervals.

The machine tool for making piston-pin holes was one of the most complex in the section. It was difficult to obtain first-class micron accuracy in these small holes, especially since hard impurities were present in the castings. The tools wore out rapidly and the machine tool turned out defective parts. There were skeptics, highly skilled specialists among them, who said that this operation could not be performed in the automatic cycle. They even proposed that it be done in a separate section on a nonautomatic machine tool. But the enthusiasts did not give up. They tried diamond boring, machining with abrasive bars, and reaming, and finally adopted hard-alloy-tipped reamers.

The aggregate lathe which rough machines the skirt grooves, head, and lands was the first machine tool of the automatic line to be built. On this machine tool, the stock is rotated and the tools are fed in. The next machine tool on the line performs the final machining of these surfaces. From here the piston goes to a checking machine which detects defects and even indicates the faulty spindle to the setup man. Next, the piston goes to an eight-spindle drilling machine which drills the oil holes. The spindles revolve at 6,000 revolutions per minute, and at this speed, the slightest overload will break the slender drills. For this reason, a special device checks the load on each tool and immediately disconnects any overloaded spindle and signals the operator when overloading occurs.

The piston then goes to the grinding machine. This is the first time such a machine tool has been built into an automatic line. It grinds the skirt and lands of two pistons simultaneously with the same grinding wheel, and an automatic device disconnects the machine tool as soon as the pistons attain the correct dimensions.

Aggregate for machining down to weight: In the first position the piston is pushed into the clamping device of the table. When the table has turned to the second position, the machine cuts off part of the inner ribs which were only temporarily necessary for mounting the piston on the holding block. In the third position, the piston is released onto a scale, and descends to a certain level, depending on its weight. In this position it is again clamped and carried to the fourth position, where a tool with constant feed cuts into it. If the piston is overweight, it descends lower than a lighter piston, and the tool removes correspondingly more metal from it, bringing it to the correct weight.

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